

COALESCER

1
2
3 This invention relates to an apparatus and method for
4 encouraging droplet growth within a two phase liquid
5 feed stream, particularly a liquid phase stream
6 comprising oil and water or solvent and water.
7 However, the invention is applicable to any fluid feed
8 stream in which there are at least two different
9 phases, for example a continuous phase and a dispersed
10 phase, a liquid phase and a non-liquid phase, or a
11 mixture of gas phases such as in gas scrubbing
12 applications.
13
14 It has been observed that for a significant number of
15 processes which generate a two phase waste flow the
16 efficiency of liquid treatment plant is no longer
17 providing the desired level of phase removal. This, in
18 many instances, is due to the feed containing
19 relatively significant volumes of the minority phase in
20 the form of small droplets (eg typically of the order
21 of 10 μm or less). These droplets provide a challenge
22 for standard phase separation devices that are commonly
23 used.
24
25 Chemical flocculants, downstream skimmed enhancement

1 vessels, centrifuges, media filters and membranes have
2 all been considered as potential enhancement mechanisms
3 to deal with the problems of small droplets.

4
5 In many instances the cost or space required to utilise
6 such technologies is limited. If small droplets can be
7 coalesced or "grown" to a greater size, then the
8 existing equipment should perform in a more efficient
9 manner.

10
11 US Patent No 3,810,832 discloses a coalescing apparatus
12 in which elongated filaments of polypropylene are
13 arranged across the flow of the mixture. The mixture
14 has to pass across the filaments of polypropylene,
15 which therefore impede the flow. US Patent No
16 4,299,699 discloses a combined coalescing/filtration
17 apparatus in which elongated strands of yarn form a
18 cylindrical assembly. The oil-in-water suspension must
19 pass from the outside to the inside of the cylindrical
20 assembly and therefore has to pass perpendicular to the
21 strands, which substantially impede the flow.

22
23 It is an object of the present invention to provide an
24 apparatus and method in which droplets in a two phase
25 liquid feed stream can be coalesced to a greater size.

26
27 According to a first aspect of the present invention
28 there is provided an apparatus for coalescing droplets
29 of one phase from a liquid comprising two or more
30 phases, the apparatus comprising a chamber, a
31 coalescing medium comprising a plurality of
32 substantially elongate members each having a surface
33 area, means for securing said coalescing medium within
34 said chamber, an inlet to said chamber, and an outlet
35 from said chamber, said inlet and outlet being
36 positioned such that liquid flowing from said inlet to

1 said outlet flows in a flow direction in contact with
2 said surface area of said coalescing medium, the
3 elongate members extending substantially in the flow
4 direction. The longitudinal members may not be
5 perfectly straight, and may be crinkled, creased,
6 twisted or irregularly deformed, but they extend in a
7 direction which is substantially parallel to the flow
8 direction, such that liquid flows along the
9 longitudinal members in contact with the surface area
10 of the coalescing medium.

11

12 Preferably said coalescing medium has a high surface
13 area per unit volume. Preferably said coalescing
14 medium comprises a plurality of elongate members in the
15 form of fibres. The fibres may be substantially
16 mutually aligned. Preferably the fibres are of
17 natural, man made or plastic material. The fibres may
18 be polypropylene, metal wire, animal hair,
19 polyethylene, polyester or glass wool. Preferably the
20 coalescing medium comprises one or more polypropylene
21 ropes. However, other forms of fibres are possible, as
22 described below:

23

24 Fibres may be prepared in a variety of cross-sectional
25 shapes according to the fluid components and
26 performance required.

27

28 The fibres may be either regular or irregular in
29 dimension and solid, hollow or open structured in
30 nature.

31

32 The fibres may be formed by spinning, weaving,
33 extruding, moulding or cellular growth as in animal or
34 plant products.

35

36 The fibres may be surface modified by smoothing,

1 roughening, chemical coating, precipitation deposition
2 or other commonly available techniques for specific
3 applications.

4

5 The fibres may be installed as separate fibres, or as
6 groups or bunches in a single or plaited grouping to
7 increase the tortuosity of the fluid flow path.

8

9 The fibres may be treated mechanically, thermally,
10 chemically or by a mixture of treatments to generate a
11 wave or curl along the length of the fibre to increase
12 the tortuosity of the fluid flow path. The fibres may
13 be of greater or lesser density than the flowing
14 fluids.

15

16 The fibres may be chosen to react to a naturally
17 occurring or artificially input component of the
18 flowing fluids to promote a change in the property of
19 the fibre. The property changes may include, but are
20 not limited to, a dimensional change due to swelling or
21 shrinking, a decrease or increase in rigidity or a
22 change of interfacial tension between the fluids and
23 the fibres.

24

25 Preferably the chamber comprises a substantially
26 straight pipe having a first end and a second end, said
27 outlet being arranged at the first end and an access
28 cover being arranged at the second end. Preferably the
29 access cover is removable such as to allow access to
30 said coalescing medium. In one embodiment the chamber
31 further comprises a branch attached to an intermediate
32 point of said pipe, said inlet being arranged at the
33 free end of said branch. However, this form of inlet
34 and outlet to the coalescing medium is not restrictive
35 and either or both of the inlet and outlet may be
36 inline, perpendicular or tangential to the direction of

1 flow within the vessel or conduit. The inlet and
2 outlet configurations need not be the same, but can be
3 adjusted to suit the design constrictions of the system
4 in which it is placed.

5
6 The application of the invention is not restricted to
7 tubular systems, but may be placed in any suitable
8 vessel or conduit which may, or may not, be open to the
9 atmosphere. The chamber of the invention is not to be
10 construed as being limited to a closed chamber, and may
11 be an open channel, for example.

12
13 The application of the invention is not limited to flow
14 systems in which the vessel, pipe or conduit is
15 completely filled with the continuous and dispersed
16 phases.

17
18 Preferably the apparatus further comprises a retaining
19 member to which the coalescing medium is secured.
20 Depending on the arrangement of the inlet and outlet,
21 the coalescing medium may comprise fibres attached to a
22 single point or to multiple points on the retaining
23 member. The multiple points may be positioned in a
24 plane transverse to the flow direction or in a plane
25 parallel to the flow direction. Suitable attachment
26 devices are apertures in the retaining member, threaded
27 clamps, clamping rings and hooks or loops on the
28 retaining member. The fibres may be bonded to the
29 retaining member by adhesive or melt bonding.

30
31 The attachment device for the fibres may include a
32 perimeter sheath within which the fibres are located to
33 promote ease of insertion or extraction from the
34 flowing fluid stream or system.

35
36 The attachment device may incorporate protective pads

1 or shields to prevent abrasion damage to the fibres due
2 to detritus in the fluid stream.

3
4 Preferably said retaining member is adapted to be
5 removably engaged within said chamber. Preferably the
6 interior of said chamber is provided with a lip adapted
7 to engage with said retaining member. Preferably said
8 access cover is adapted to hold said retaining member
9 against said lip when the access cover is attached to
10 the pipe. Preferably said retaining member is provided
11 with one or more apertures for securing said coalescing
12 medium to said retaining member.

13
14 According to a second aspect of the present invention
15 there is provided a method for coalescing droplets of
16 one phase from a liquid comprising two or more phases,
17 in which the liquid is caused to flow through a chamber
18 in which is secured a coalescing medium having a
19 surface area, such that the liquid flows in contact
20 with said surface area of said coalescing medium and
21 droplets of a phase of said liquid coalesce on said
22 surface area. Preferably the method uses an apparatus
23 according to the first aspect of the present invention.

24
25 The present invention provides a simple process unit
26 which can either be added to a process system when the
27 system is constructed or be retrofitted into an
28 existing process system to increase the efficiency
29 and/or life of the process system. The coalescer
30 utilises additional surface area within the pipe to
31 assist the minority phase droplets to coalesce.

32
33 In one embodiment the apparatus of the invention
34 comprises a length of pipe fitted at each end with a
35 pressure sealable fitting (eg a flange plate, which can
36 be fixed to the pipe by welding, screw thread etc). At

1 one end of the pipe there is a "T" section fitted, with
2 another pressure sealable fitting (eg a flange plate,
3 again fixed by welding, screw thread etc). The
4 pressure sealable fitting on the pipe closest to the
5 "T" section is blanked off, and acts as a service and
6 inspection access point for the coalescing retainer and
7 media.

8
9 The coalescing media extends within the pipe through
10 the length of the unit and is retained by a retainer.
11 The media retainer may be of disk type construction,
12 and may have a number of drill holes therethrough to
13 allow the media to be attached. The retainer is
14 constructed from a stainless steel, or other suitable
15 material that will not be prone to corrosion or wear in
16 the environment under which this invention will have to
17 operate. The media retainer is secured in position by
18 appropriate means, for example by clamping between the
19 shoulder of the pipe and the screw fitting of the
20 blanketing plug, or by the retainer being restrained in
21 the pipe by a welded lip/shoulder and being held in
22 position by the flow of fluid around the media. It is
23 envisaged that the coalescing media will be made from
24 fibrous man-made or natural material such as
25 polypropylene rope, metal wire, animal hair,
26 polyethylene, polyester or glass wool.

27
28 To ensure that the coalescing media is correct for the
29 accumulation and thus the coalescing of the minority
30 phase this invention will allow for the coalescing
31 media to be fully interchangeable. The size and
32 dimensional shape of the coalescer will be dependent on
33 the flow characteristics of the fluid flowing through
34 the apparatus, such as Reynolds Number, fluid type,
35 dispersed phase size, desired level of dispersed phase
36 coalescence, desired or allowable system pressure drop,

1 system temperature, flow volume, and weight and space
2 restrictions. For example, if a high Reynolds Number
3 is required, a smaller effective cross sectional area
4 is required for the same flow. In the case of a
5 chamber formed by a pipe, this could be achieved by
6 either reducing the pipe diameter, or increasing the
7 cross sectional area that is occupied by the coalescing
8 media. Typically the pipe may be between 10mm and
9 100mm in diameter, although larger pipes may be used.

10

11 A specific embodiment of the invention will now be
12 described, by way of example only, with reference to
13 the drawings in which:

14

15 Fig 1 shows a schematic perspective view of an
16 apparatus according to one embodiment of the invention
17 indicating the location of the pressure sealable
18 fittings, with a partial cut away view showing the
19 coalescing medium inside the pipe;

20

21 Fig 2 shows a longitudinal cross section of the
22 apparatus of Fig 1, indicating the construction of the
23 media retainer and the extent that the coalescing media
24 extends through the unit;

25

26 Fig 3 shows a detail on the retaining plate of the
27 apparatus of Fig 1;

28

29 Fig 4 shows a detail of an alternative to the retaining
30 plate of Fig 3, in which the coalescing media is
31 secured to a retaining pin; and

32

33 Figs 5 to 7 are graphs of results of test carried out
34 using the apparatus of Fig 1, showing the percentage
35 gain in oil droplet diameter for different coalescing
36 media fibres.

1 With reference to Figs 1 to 4, the coalescer 10
2 comprises a pipe 1 of suitable diameter to allow for
3 the required flow characteristics. Typically the
4 coalescer of the example has an internal diameter of
5 100 mm and a length of 2 m. The pipe 1 has an inlet 21
6 at the end of an inlet branch 20, which is connected to
7 the pipe near a first end of the pipe. At the second
8 end of the pipe is an outlet 22.

9
10 The pipe 1 is fitted into the process system/train by
11 use of the pressure sealable fittings 23, 24, which
12 each comprise flanges provided with apertures 25 for
13 bolted connections.

14
15 Inside the pipe 1 are the coalescing media 5, which are
16 supported at one end only by a media retainer plate 4.
17 The media 5 may be bundles 15 of fibres 30 secured
18 through apertures 11 in the media retaining plate 4 by
19 means of a knot 8, as shown in detail in Fig. 3. The
20 fibres 30 are then free to extend along the interior of
21 the pipe towards the second end under the action of
22 liquid flowing along the pipe towards the outlet 22.
23 Alternatively the fibres 30 may be a single bundle 17
24 of individual fibres folded in half around a media
25 retaining pin 14, and secured to the pin 14 by a tie 18
26 which encircles the folded bundle 17.

27
28 Access to the coalescer media retainer 4, 14 and media
29 5 is achieved via the inspection and maintenance access
30 point 3. The media retainer 4, 14 may be secured in
31 position by any suitable means. In the example shown
32 in Fig. 2, the media retaining plate 4 is held by the
33 clamping action of a threaded cover plate 6 against a
34 shoulder 7 formed within the pipe 1.

35
36 The coalescer media 5 is attached to the media retainer

1 4, 14 by any suitable method, depending on the media
2 that is used. If polypropylene rope is used for the
3 media 5, connection is achieved by means of knots 8
4 tied in the ends, as shown in Fig. 2. The individual
5 ropes or strands 9 of rope are passed through preformed
6 apertures 11 in the media retaining plate 4, so that
7 the knots prevent the rope from becoming detached from
8 the media retaining plate 4. The ropes may
9 alternatively be secured by clamps, glue or thermal
10 fusing, as will be apparent to those skilled in the
11 art. The media 5 may be provided with a sleeve (not
12 shown) which surrounds the fibres nearest the retaining
13 plate 4, in order to protect the fibres 30 during
14 insertion of the media into the pipe. The media 5 may
15 be provided with protective pads or shields (not shown)
16 around the point of attachment to the retaining plate
17 4, in order to prevent abrasion damage to the fibres 30
18 due to detritus in the fluid stream.

19
20 In use the two phase liquid enters the apparatus
21 through inlet 21 and passes along the pipe 1. The
22 large number of fibres 30 in the coalescing medium 5
23 means that there is a large surface area of the medium
24 in contact with the fluid as it passes along the pipe 1
25 to the outlet 22, encouraging the formation and growth
26 of droplets of the minority phase on the fibres 30.

27
28 When the coalescing medium 5 needs to be replaced, the
29 cover plate 6 is unscrewed, the media retainer 4, 14
30 can be removed and a new medium 5 is attached to the
31 retainer 4, 14. Alternatively a new complete unit
32 comprising a retainer 4, 14 with the media preattached
33 is used. The retainer 4, 14 is then reinserted in the
34 pipe 1 and the cover plate 6 screwed in.

35
36 The invention offers significant advantages over prior

1 art coalescers. Since the fibres 30 are oriented in
2 the flow direction, there is reduced flow resistance
3 created. The only resistance to flow arises from the
4 shear stress between the liquid and the fibres. This
5 is of particular importance when the apparatus of the
6 invention is used in a low pressure process train.
7 Tests have shown that pressure drops across the
8 coalescer of the invention of less than 1.0 bar may be
9 achieved. This compares with a pressure drop of 1.8
10 bar when using a prior art hydrocyclone coalescer. The
11 apparatus of the invention can operate successfully
12 under a range of flow conditions, coalescing droplets
13 of less than 10 micron diameter with flow conditions
14 varying from Re (Reynolds Number) 30,000 to 100,000.
15 Tests show that if the invention is used with a
16 hydrocyclone, the efficiency of the hydrocyclone can be
17 improved from 30% to 90% for small droplet sizes.

18
19 The coalescer of the invention may be easily
20 retrofitted. It has a low cost, since low cost fibres
21 such as polypropylene, nylon, hemp, cotton and hair may
22 be used for the coalescing fibre. The best results
23 have been obtained with polypropylene in the form of
24 rope, mop or ribbon-type strands such as Sorbaine (TM).

25
26 The coalescing apparatus of the invention is used to
27 form larger droplets of the minority phase in the fluid
28 stream. Its effectiveness can be measured by the
29 increase in droplet size which it achieves. Larger
30 droplets may be separated more effectively by a
31 cyclone, so that the passing of a fluid stream through
32 a coalescing apparatus according to the invention
33 before passing the fluid stream to a cyclone or other
34 separation device improves the efficiency of the
35 separation device.

36

1 EXAMPLES

2
3 Tests have been carried out to measure the effect on
4 droplet size of different coalescing media. The
5 results, using water and oil at 50°C in a test
6 apparatus similar to that shown in Figs 1 and 2, are
7 shown in Figs 5 to 7. Sorbaine (TM) is a proprietary
8 polypropylene fibre in ribbon form. Fig 5 shows that
9 under high flow conditions (Reynolds Number 50,000)
10 polypropylene mop (a tortuous polypropylene fibre) and
11 hemp string achieved oil droplet size growth of more
12 than 40%. Fig 6 shows that under medium flow
13 conditions (Reynolds Number 30,000) polypropylene mop
14 and Sorbaine both achieved oil droplet size growth of
15 more than 40%. Fig 7 shows that under low flow
16 conditions (Reynolds Number 15,000) Sorbaine achieved
17 oil droplet size growth of more than 40%.

1 The modifications described in this specification and
2 other modifications and improvements can be
3 incorporated without departing from the scope of the
4 invention as defined in the appended claims.